# RFSA2654

## SERIAL CONTROLLED 75Ω DIGITAL STEP ATTENUATOR 5MHz TO 2000MHz, 6-BIT, 0.5dB

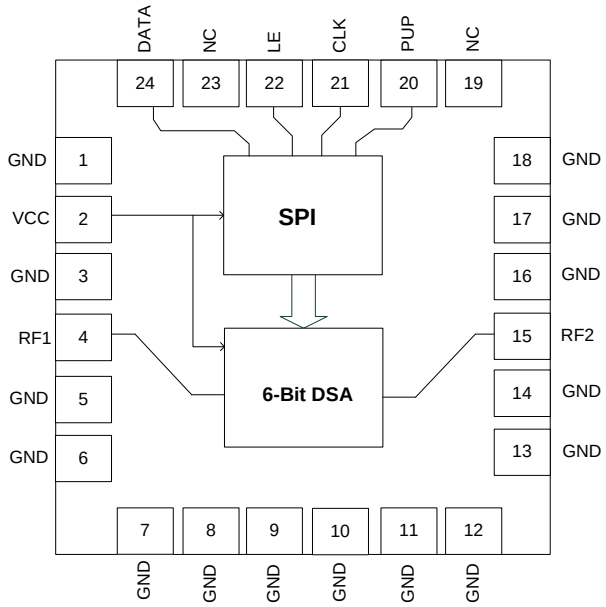
Package: MCM, 24-Pin, 4.2mm x 4.2mm


## Features

- Frequency Range 5MHz to 2000MHz
- 6-Bits, 75Ω, 31.5dB Range, 0.5dB Step
- High Linearity, IIP3 >50dBm
- 3V and 5V Logic Compatible
- Serial-to-Parallel Controller
- Serial Programming Interface
- Power-up Programming Modes
- On-chip ESD Protection Class 1C HBM
- Single Supply, 5V Operation
- Footprint Compatible with Most 24-Pin, 4mm x 4mm, QFNs

## Applications

- CATV/Satellite Set Top Boxes
- Cable Modems
- CATV Infrastructure
- Data Network Equipment




Functional Block Diagram

## Product Description

RFMD's RFSA2654 is a 6-bit, 75Ω digital step attenuator (DSA) that features high linearity over the entire 31.5dB gain control range with excellent step accuracy in 0.5dB steps. The RFSA2654 is programmed via a serial mode control interface that is both 3V and 5V compatible. The RFSA2654 also offers a rugged Class 1C HBM ESD rating via on-chip ESD circuitry. The MCM package is footprint compatible with most 24-pin 4mm x 4mm QFN packages.

### Ordering Information

| | |
|---|---|
| RFSA2654SQ | Sample bag with 25 pieces |
| RFSA2654SR | 7” Sample reel with 100 pieces |
| RFSA2654TR13 | 13” Reel with 2500 pieces |
| RFSA2654PCK-410 | 5MHz to 2000MHz PCBA with 5-piece sample bag |

### Optimum Technology Matching® Applied

| | | | |
|---|---|---|---|
| ☐ GaAs HBT | ☐ SiGe BiCMOS | ☑ GaAs pHEMT | ☐ GaN HEMT |
| ☐ GaAs MESFET | ☐ Si BiCMOS | ☑ Si CMOS | ☐ BiFET HBT |
| ☐ InGaP HBT | ☐ SiGe HBT | ☐ Si BJT | |





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## Absolute Maximum Ratings

| Parameter | Rating | Unit |
|---|---|---|
| Supply Voltage | +5.5 | V |
| DC Supply Current | 15 | mA |
| Power Dissipation | 83 | mW |
| Max RF Input Power | 28.3 | dBm |
| Operating Temperature ($T_{CASE}$) | -40 to +85 | °C |
| Storage Temperature | -40 to +150 | °C |
| Junction Temperature | 150 | °C |
| ESD Rating (HBM) | Class 1C | |
| Moisture Sensitivity Level | MSL3 | |

**Caution!** ESD sensitive device.

Exceeding any one or a combination of the Absolute Maximum Rating conditions may cause permanent damage to the device. Extended application of Absolute Maximum Rating conditions to the device may reduce device reliability. Specified typical performance or functional operation of the device under Absolute Maximum Rating conditions is not implied.



RFMD Green: RoHS compliant per EU Directive 2002/95/EC, halogen free per IEC 61249-2-21, < 1000ppm each of antimony trioxide in polymeric materials and red phosphorus as a flame retardant, and <2% antimony in solder.

## Nominal Operating Parameters

| Parameter | Specification | | | Unit | Condition |
|---|---|---|---|---|---|
| | Min. | Typ. | Max. | | |
| **Overall** | | | | | 5V, 25 °C, 75Ω, typical condition unless otherwise stated. |
| Frequency Range | 5 | | 2000 | MHz | |
| Insertion Loss | | 0.69 | | dB | 5MHz, 0dB attenuation |
| | | 1.3 | | dB | 880MHz, 0dB attenuation |
| | | 1.92 | | dB | 1200MHz, 0dB attenuation |
| | | 2.21 | | dB | 1880MHz, 0dB attenuation |
| | | 2.29 | | dB | 2000MHz, 0dB attenuation |
| Gain Control Range | | 31.5 | | dB | 0.5dB step size |
| Step Accuracy | ±(0.1 + 5.0% attenuation setting) | | | dB | |
| Input IP3 | 46 | 52 | | dBm | 30MHz to 2000MHz, all states, tested into 50Ω, minimum at 31.5dbm attenuation |
| Input P0.5dB | | 25 | | dBm | 100MHz, all states, tested into 50Ω |
| | 27 | 30 | | dBm | 200MHz to 2000MHz, 27dBm for 8, 16-bit Steps, tested into 50Ω |
| Input Return Loss | 11 | 17.5 | | dB | 5MHz to 1200MHz, all states |
| Output Return Loss | 11 | 17.5 | | dB | 5MHz to 1200MHz, all states |
| Control Interface | | 6-bit, Serial | | bit | Serial interface |
| Settling Time | | 200 | | ns | $t_{RISE}$, $t_{FALL}$ (10%/90% RF) |
| Switching Speed | | 200 | | ns | $t_{ON}$, $t_{OFF}$ (50% CTL to 10%/90% RF) |
| Supply Voltage ($V_{DD}$) | 4.75 | 5.0 | 5.25 | V | Typical performance based on 5V operation. |
| Supply Current | | 5.7 | | mA | |
| Control Voltage ($V_{CTL}$) | Low, $V_{CTL}$ = 0V to 0.8V | | | V | |
| | High, $V_{CTL}$ = 2.0V to $V_{DD}$ | | | V | |

Notes:
1. $V_{DD}$ = 5V, $V_{CTL}$ = 5V, T = 25 °C
2. IIP3 measured with $P_{IN}$ = +12dBm/tone, 1MHz spacing



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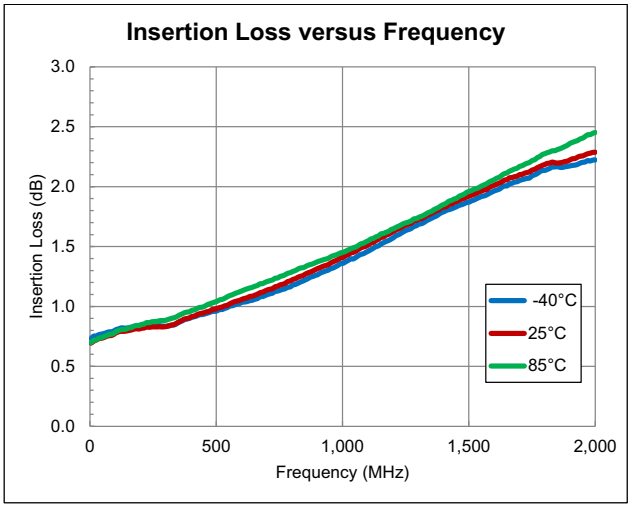
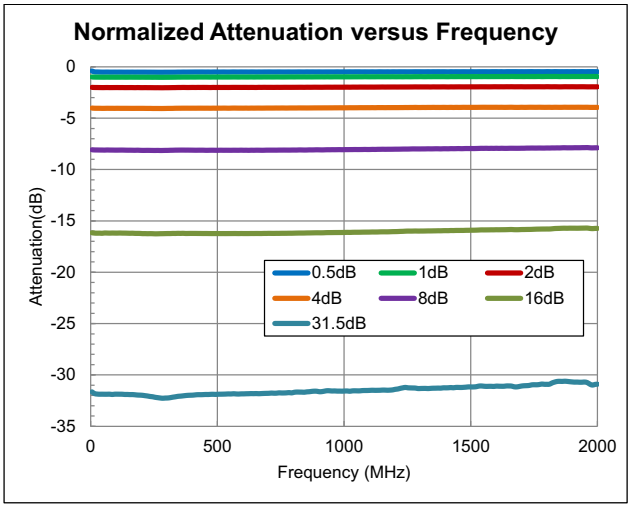
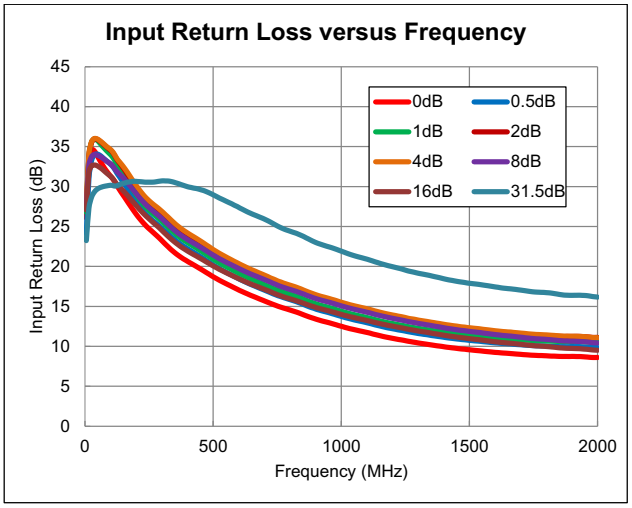
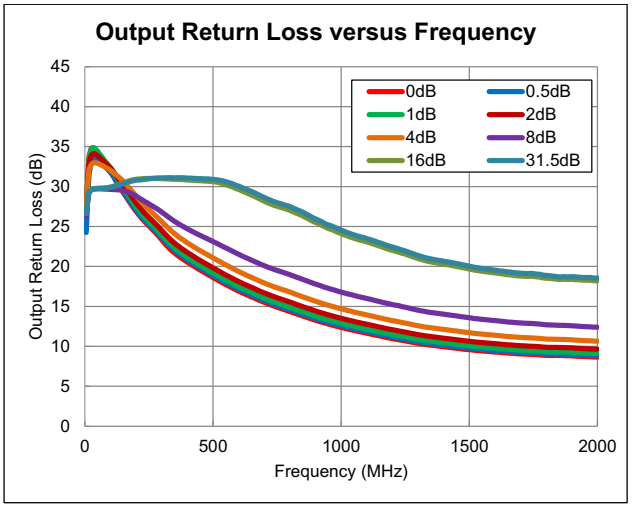
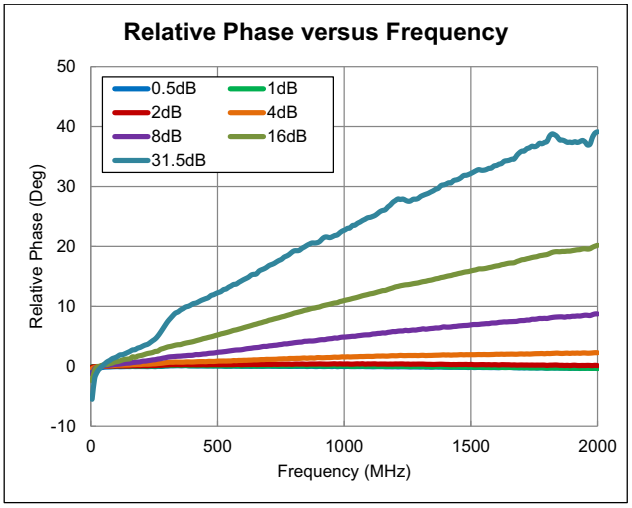
## Typical Performance - Broadband Application Circuit

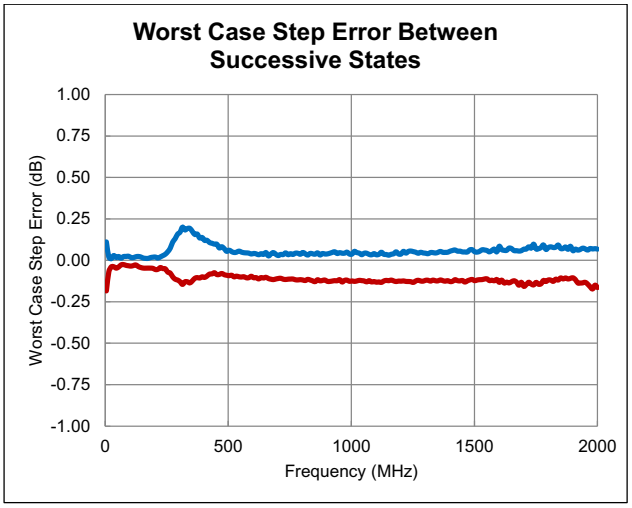


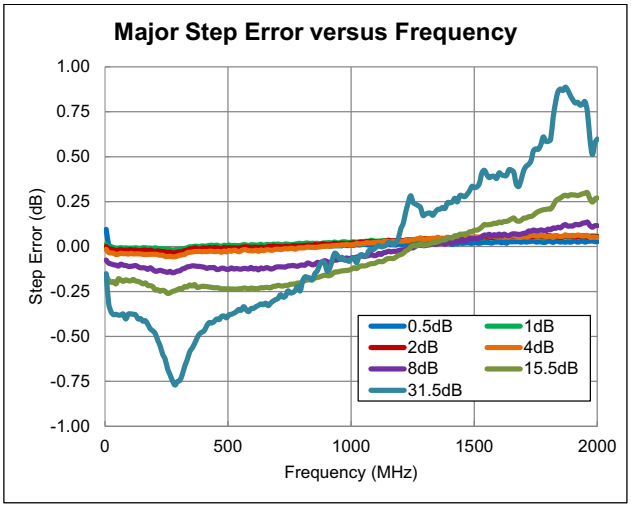



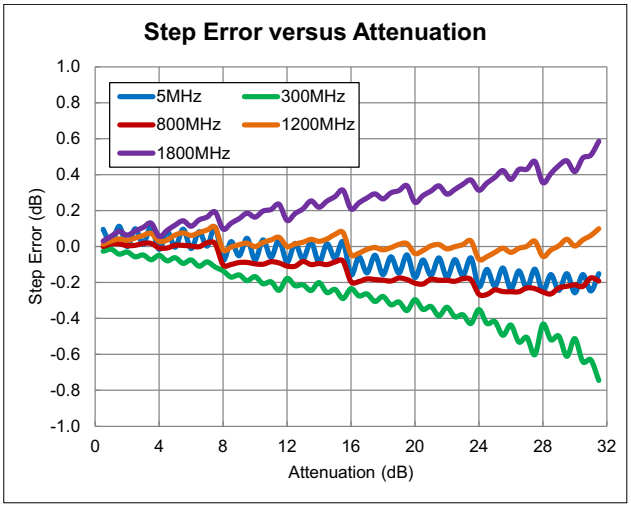



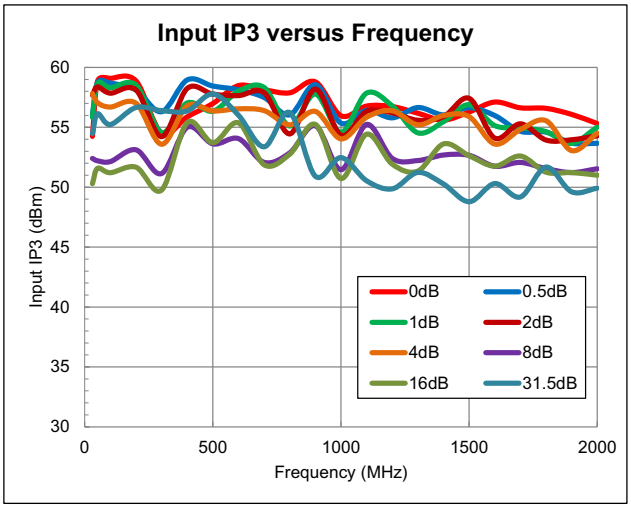



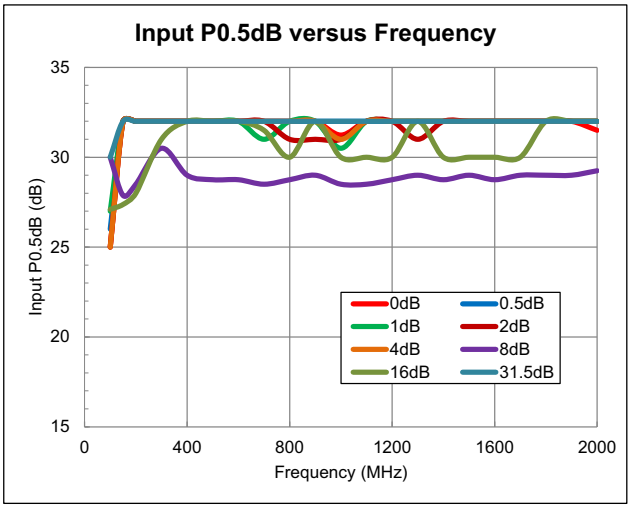



## Typical Performance - Broadband Application Circuit



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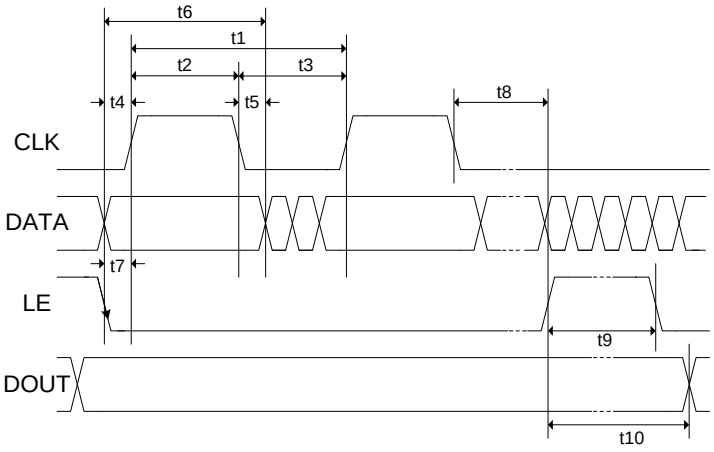
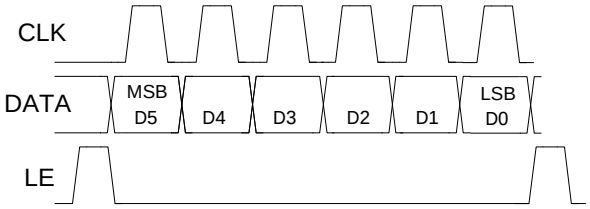
## Serial Port Interface

SPI Timing Diagram




Programming Example - 6-Bit




## Truth Table

| Control Bits | | | | | | Relative Gain Setting |
|---|---|---|---|---|---|---|
| C16 | C8 | C4 | C2 | C1 | C0.5 | |
| 1 | 1 | 1 | 1 | 1 | 1 | Max gain |
| 1 | 1 | 1 | 1 | 1 | 0 | -0.5dB |
| 1 | 1 | 1 | 1 | 0 | 1 | -1dB |
| 1 | 1 | 1 | 0 | 1 | 1 | -2dB |
| 1 | 1 | 0 | 1 | 1 | 1 | -4dB |
| 1 | 0 | 1 | 1 | 1 | 1 | -8dB |
| 0 | 1 | 1 | 1 | 1 | 1 | -16dB |
| 0 | 0 | 0 | 0 | 0 | 0 | -31.5dB |

## SPI Timing Diagram Specifications

| Parameter | Limit | Unit | Comment |
|---|---|---|---|
| t1 | 25 | MHz max | CLK Frequency |
| t2 | 20 | ns min | CLK High |
| t3 | 20 | ns min | CLK Low |
| t4 | 5 | ns min | DATA to CLK Setup Time |
| t5 | 5 | ns min | DATA to CLK Hold Time |
| t6 | 30 | ns min | Data Valid |
| t7 | 5 | ns min | LE to CLK Setup Time |
| t8 | 5 | ns min | CLK to LE Setup Time |
| t9 | 10 | ns min | LE Pulse Width |
| t10 | 20 | ns min | Output Set |

| Logic Voltage Levels | |
|---|---|
| State | Logic |
| Low | 0V to 0.8V |
| High | 2.0V to 5.0V |

| Power-up Programming Truth Table | |
|---|---|
| PUP | Attenuator Setting |
| Low | Attenuation at max, 31.5dB |
| High | Attenuation at min, 0dB |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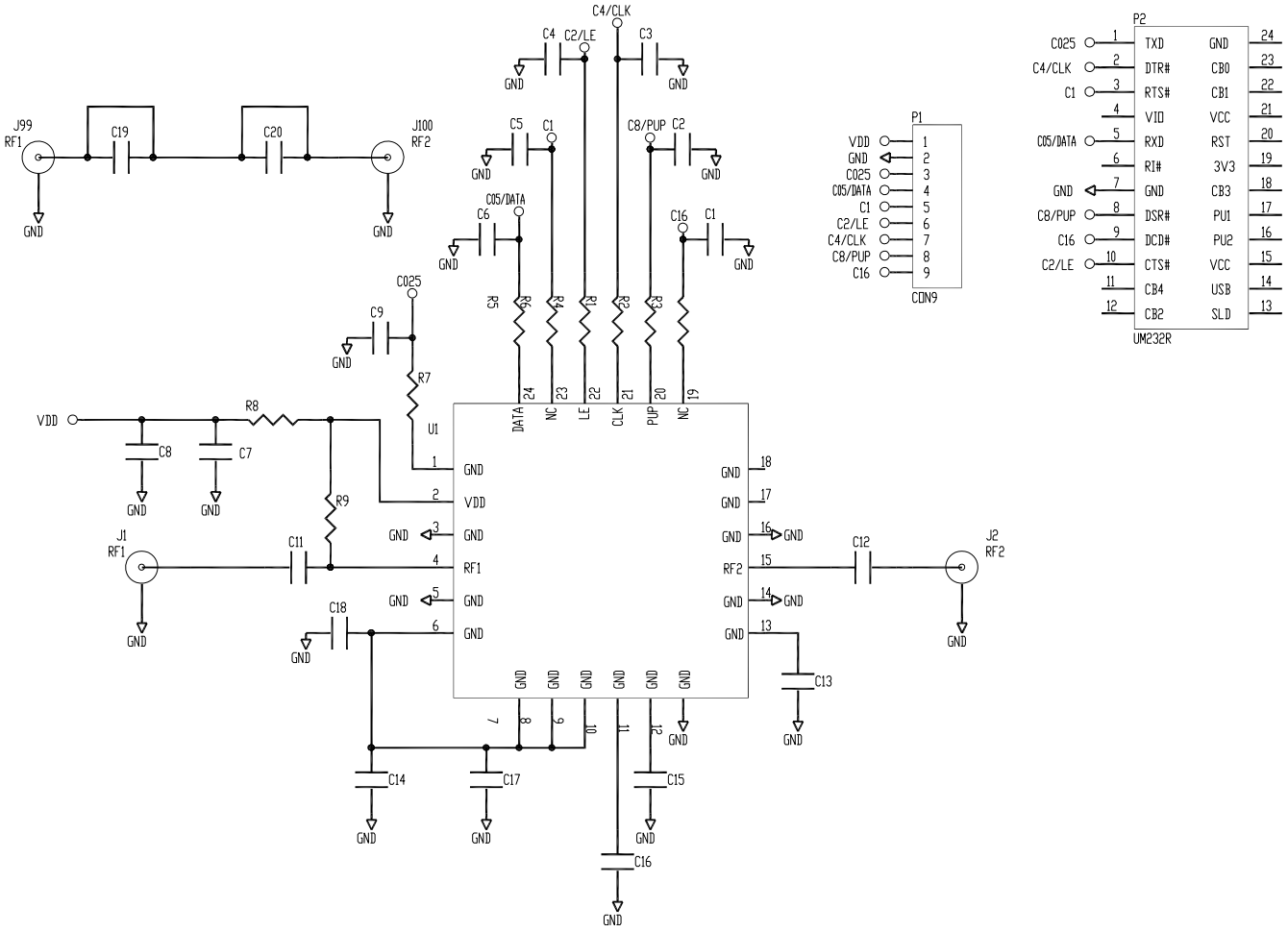
## Evaluation Board Schematic




## Evaluation Board Bill of Materials (BOM)

| Description | Reference Designator | Manufacturer | Manufacturer's P/N |
|---|---|---|---|
| Evaluation Board | | | SA2654410(A |
| RFSA2654 | U1 | RFMD | RFSA2654 |
| CAP, 1nF, 10%, 10V, X5R, 0402 | C7 | Taiyo Yuden (USA), Inc. | RM UMK105BJ102KV-F |
| CAP, 10000pF, 10%, 25V, X7R, 0402 | C11-C12* | Murata Electronics | GRM155R71E103KA01D |
| RES, 0Ω, 5%, 1/16W, 0402 | R1-R2, R4-R5, R8 | Kamaya, Inc | RMC1/16SJPTH |
| DNP | R3, R6-R7, R9 | | |
| DNP | C1-C6, C8-C9, C13-C20 | | |
| CONN, F FEM EDGE MOUNT, 75Ω, 0.035" | J1-J2 | Millimeter Wave Technologies, LLC | MW-846-F-DD-75 |
| DNP | J99-J100 | | |
| CONN, HDR, ST, PLRZD, 9-PIN | P1 | ITW Pancon | MPSS100-9-C |
| CONN, SKT, 24-PIN DIP, .600", T/H | P2 | Aries Electronics Inc. | 24-6518-10 |

* Evaluation board shipped with 470pF C11-C12 to support 2GHz operation. 10,000pF required for 5MHz operation.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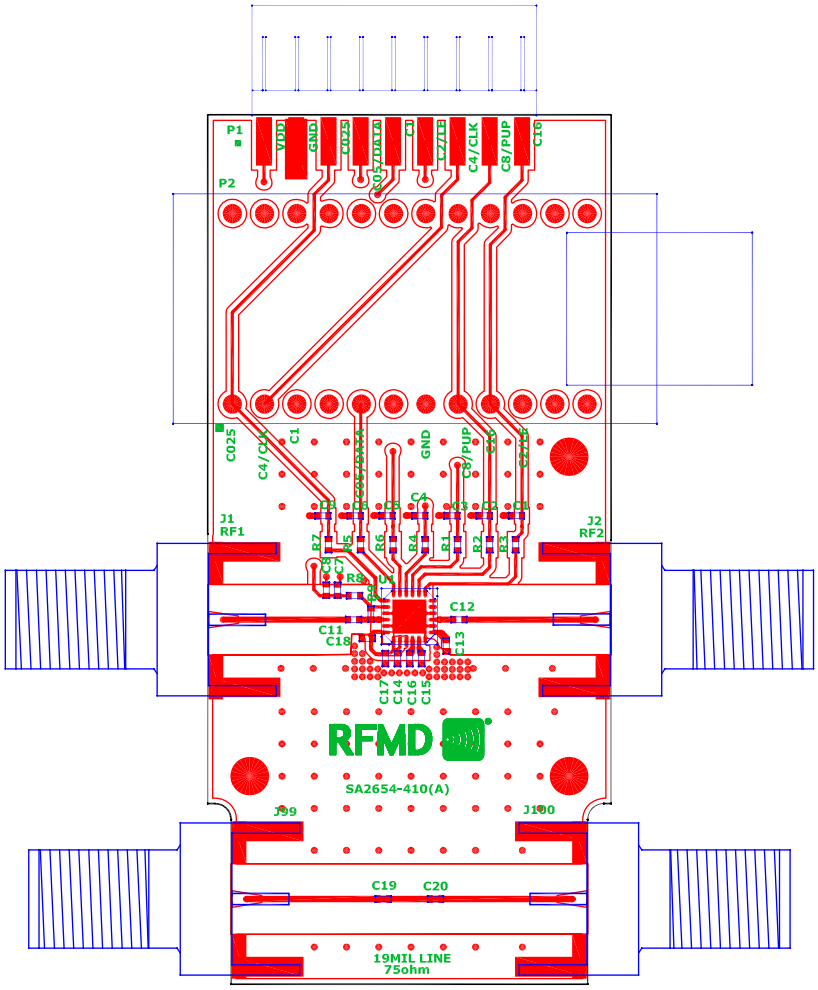
## Evaluation Board Assembly Drawing



## Pin Names and Descriptions

| Pin | Name | Description |
|---|---|---|
| 1 | GND | Connect to Low Inductance Path to Ground. |
| 2 | VDD | Power Supply. |
| 3 | GND | Connect to Low Inductance Path to Ground. |
| 4 | RF1 | RF port. External DC block required. |
| 5 | GND | Connect to Low Inductance Path to Ground. |
| 6 | GND | Connect to Low Inductance Path to Ground. |
| 7 | GND | Connect to Low Inductance Path to Ground. |
| 8 | GND | Connect to Low Inductance Path to Ground. |
| 9 | GND | Connect to Low Inductance Path to Ground. |
| 10 | GND | Connect to Low Inductance Path to Ground. |
| 11 | GND | Connect to Low Inductance Path to Ground. |
| 12 | GND | Connect to Low Inductance Path to Ground. |
| 13 | GND | Connect to Low Inductance Path to Ground. |
| 14 | GND | Connect to Low Inductance Path to Ground. |
| 15 | RF2 | RF port. External DC block required. |
| 16 | GND | Connect to Low Inductance Path to Ground. |
| 17 | GND | Connect to Low Inductance Path to Ground. |
| 18 | GND | Connect to Low Inductance Path to Ground. |
| 19 | NC | No internal connection. EVB can be ground or no connect. |
| 20 | PUP | Power-up Programming pin.<br>Low = max attenuation (31.5dB) at power-up.<br>High = min attenuation (0dB) at power-up. |
| 21 | CLK | Serial Clock. |
| 22 | LE | Latch Enable. |
| 23 | NC | No internal connection; EVB can be ground or no connect. |
| 24 | DATA | Serial Data. |
| EPAD | GND | DC and RF Ground; Must be soldered to EVB ground plane over a bed of vias for thermal and RF performance. |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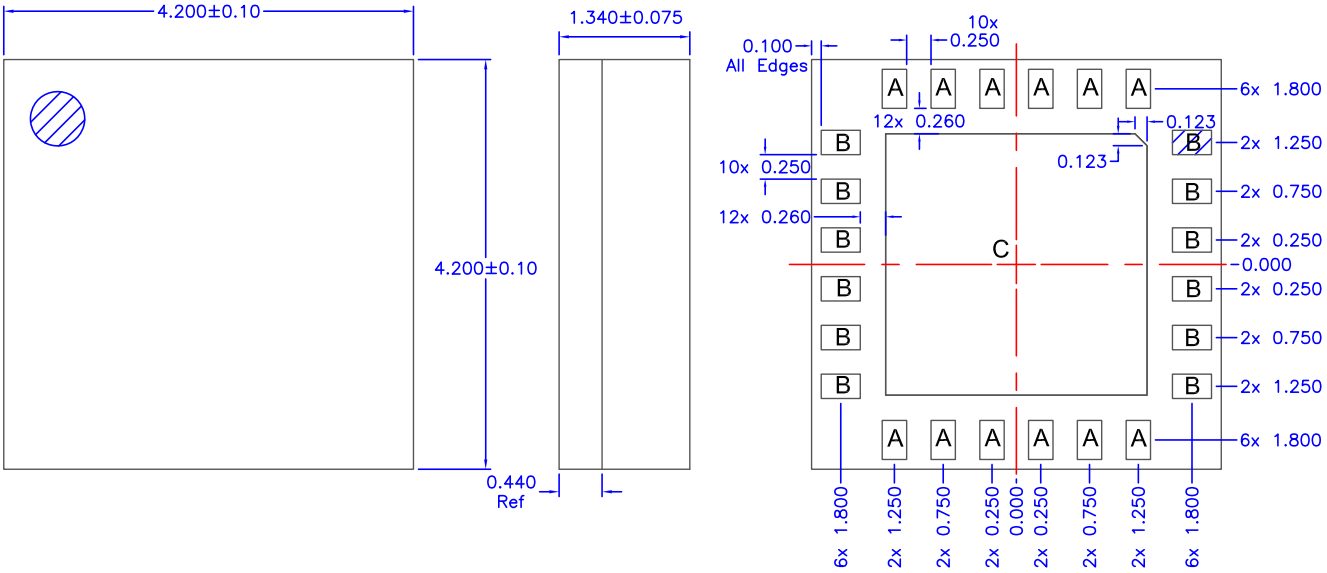
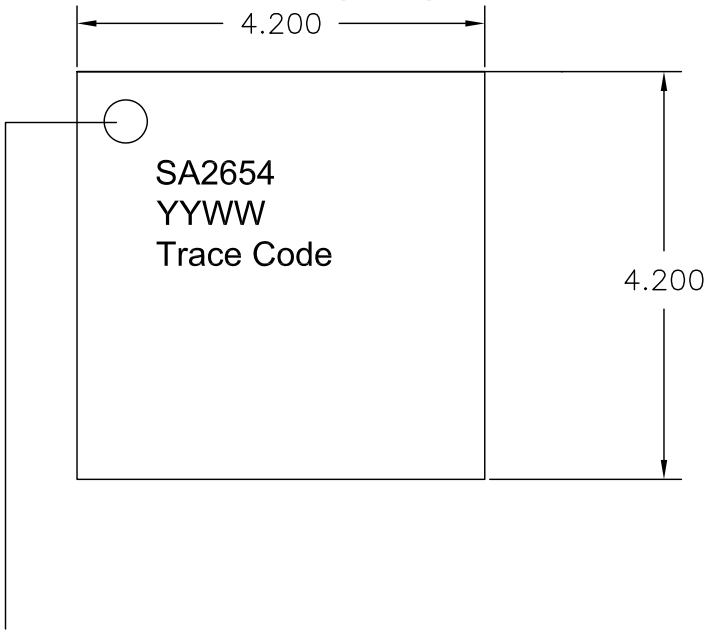
## Package Drawing




Notes:
1. Shaded area represents Pin 1 location.

A = 0.250 x 0.400 mm
B = 0.400 x 0.250 mm
C = 2.680 x 2.680 mm

## Branding Diagram




Pin 1 Indicator
YY = Year
WW = Week